International Bioenergy R&D Strategy –
A Plan in Support of Domestic Programs

USDA

United States Department of Agriculture
Research, Education, and Economics

ARS

Agricultural Research Service

Office of International Research Programs

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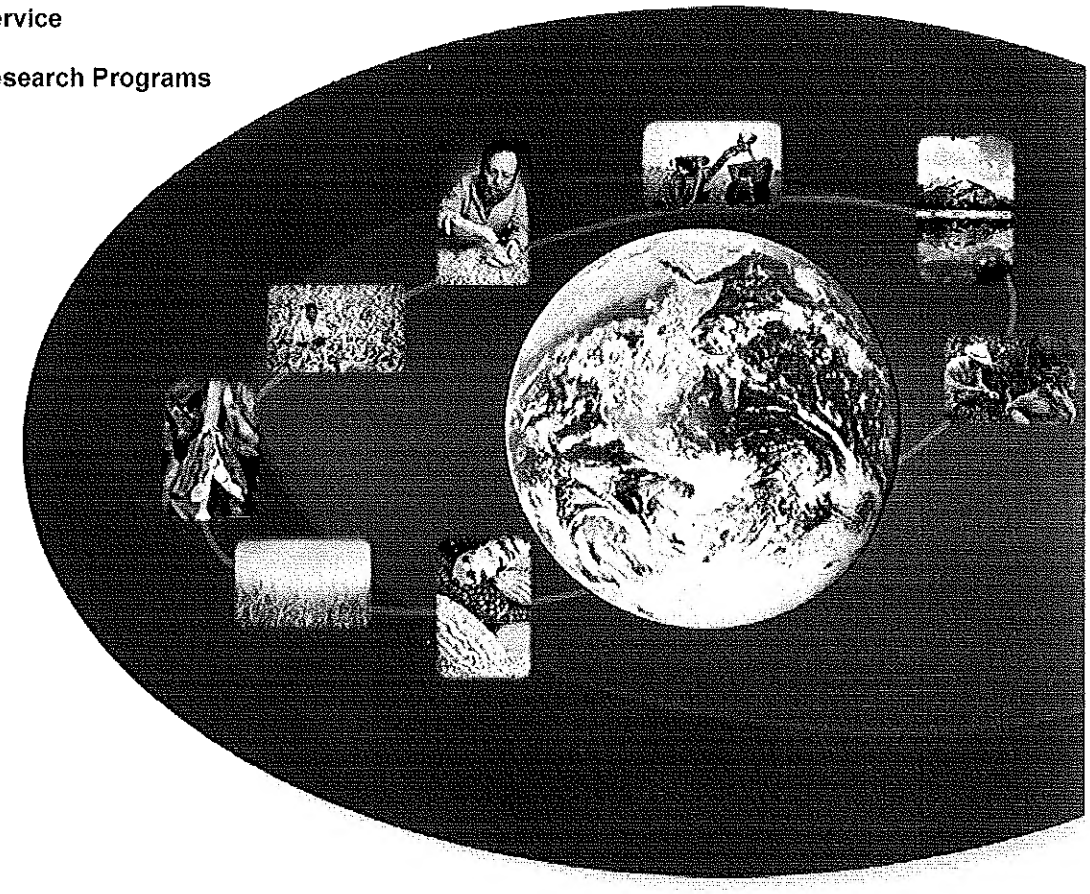

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Executive Summary

1.0 OIRP Mission and Benefits of International Partnerships

The mission of the USDA Agricultural Research Service (ARS; see Appendix I) - Office of International Research Programs (OIRP) is to enhance the effectiveness and impact of US agriculture through international research activities. OIRP Directors and International Affairs Specialists work closely with numerous domestic and international entities to facilitate international research activities which:

- Extend the capacity of the ARS National Programs to address problems confronting U.S. agriculture
- Promote participation in the scientific community to expedite the exchange of innovations, data and germplasm
- Facilitate international cooperation and collaboration on mutually beneficial high priority agricultural research[1]

OIRP was formed in October 1999, driven in part by the needs identified by the World Food Summit and the US Action Plan on Food Security (1999).[2] OIRP facilitates international collaboration in areas such as food safety, pathogen/pest characterization and crop protection, and livestock health and production, all of which are extremely important considerations for a growing world population and a global economy. ARS scientists, working with OIRP, have successfully addressed numerous global challenges regarding trade, science and technology innovation, and homeland security.

The work by OIRP staff to facilitate international research and development (R&D) partnerships extends many benefits to ARS, and the US at large. Through international partnerships, ARS scientists are afforded access to supportive data and materials which may not be accessible in the US. International exchanges can accelerate scientific discovery and ultimately increase the potential for ARS to impact positive change in the US and around the globe. These partnerships also serve as a catalyst for further collaboration and impact (see sidebar *Labex – a scientific multiplier*[3] Appendix I). Yet these benefits also extend beyond the agency to the nation at large by enhancing US competitiveness in a global market, speeding commercialization of technology or products, and securing trade of agricultural commodities. These partnerships are also effective at addressing global problems which are potentially destabilizing to national economies, including the US, and serve as a valuable element to the nation's foreign policy by breeding thought exchange and goodwill.

OIRP International Affairs Specialists manage international programs in many topical R&D areas across seven global regions: Asia, Central and South America, Europe, Former Soviet Union (Scientific Coordination Program), Middle East and North Africa, North America, and Sub Saharan Africa.

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[1] http://www.ars.usda.gov/research/docs.htm?docid=1428
[2] McBride, Judy. "Spinning a Global Web for Agricultural Science". *Agricultural Research*. **2001**, *49* (4), 4-8.
[3] Kaplan, J. Kim. "LABEX: A Successful Partnership from Way Down South". *Agricultural Research*. **2001**, *49* (12), 8-13.

1.2 OIRP Objectives for the International Bioenergy R&D Plan

Bioenergy, which refers primarily to fuels and power, but also to products, derived from renewable agricultural or forestry materials, has emerged as a high priority area for the nation and international community. Spurred by unprecedented petroleum prices and government support, biofuels, such as ethanol (currently produced from sugarcane and corn grain) and biodiesel (currently produced primarily from soybean, rapeseed/canola, and palm), are now produced in at least 20 countries as an economically competitive and environmentally friendly alternative to petroleum, as a source of liquid transportation fuel.

Significant annual increases in bioenergy production are being driven largely by energy security concerns, the awareness of climate change mitigation, and new global policies (Figure 1). For countries such as the United States, biofuels produced from domestic feedstocks offer an opportunity to offset the nation's increasing petroleum imports from geopolitically sensitive foreign sources.

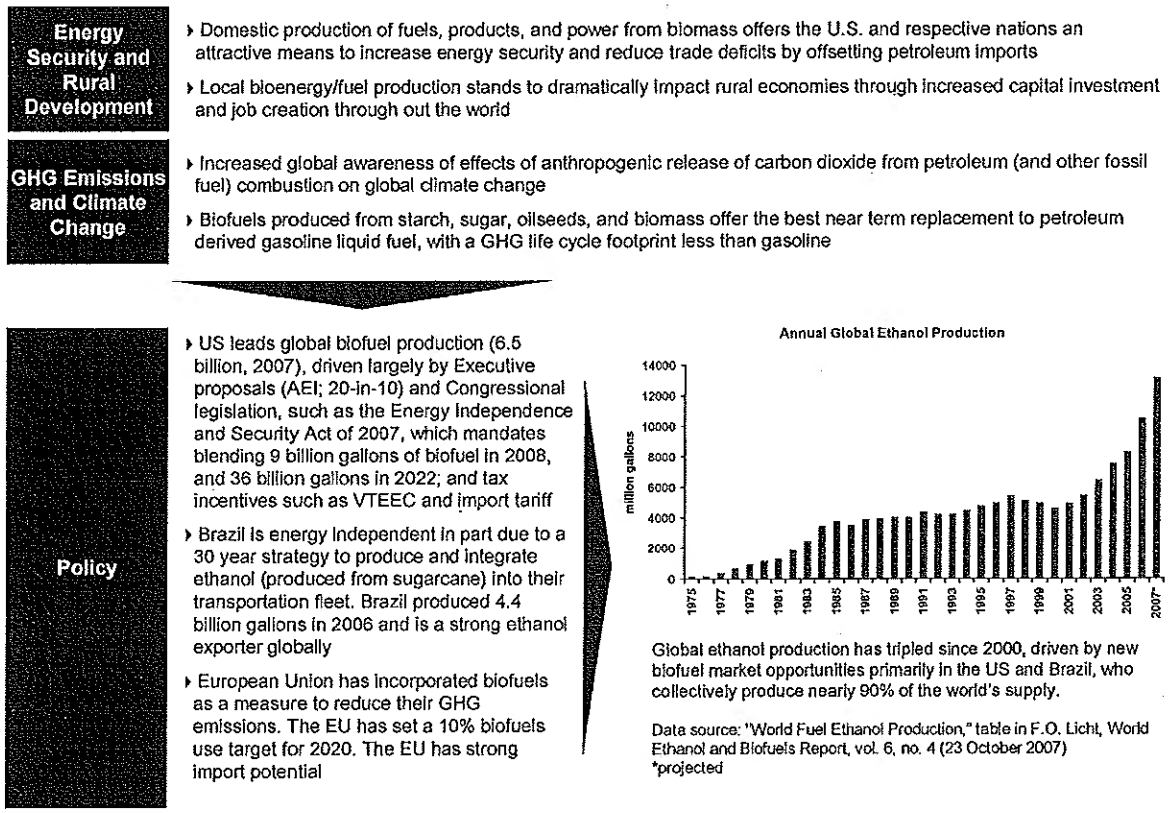


Figure 1. Drivers for increasing global ethanol biofuel production.

ARS OIRP understands that bioenergy R&D is a global opportunity area which transcends domestic borders, and recognizes the importance of global bioenergy partnerships to:

- Extend the impact of ARS bioenergy research
- Gain valuable knowledge and materials not accessible in the US
- Promote and accelerate sustainable global bioenergy production

With the ambition to more effectively support global bioenergy development, OIRP developed an *International Bioenergy R&D Strategy*, as reported here. The primary objective of this strategy document is to identify international bioenergy R&D areas which complement and add value to the three component areas of the ARS Bioenergy National Program (see Appendix II):

- Feedstock Development
- Feedstock Production
- Conversion and Co-products

The *International Bioenergy R&D Strategy* is intended to increase coordination between ARS National Programs and OIRP by promoting the engagement of a common set of issues important to both domestic stakeholders and international partners (Figure 2). This plan also proposes action steps to drive OIRP strategic planning and decision making.

The expected outcomes of the *International Bioenergy R&D Strategy* are to:

- Increase OIRP involvement in National Program strategic planning
- Improve the effectiveness of OIRP specialists through more efficient targeting of the most relevant international bioenergy R&D partnership areas
- Enhance the function of OIRP with actions to help the Bioenergy National Program achieve greater impact through international partnerships

Bioenergy presents opportunities for many nations to produce their own fuels and products, and reduce their dependence on petroleum imports. Yet due to natural resource challenges and an ever increasing world population, the demands placed on world agricultural systems, to produce enough food, feed, fiber, and now fuel, in a sustainable manner are multiplying rapidly. Agricultural R&D is required to meet these challenges directly and with a global perspective to promote the enhancement of natural resources while continuing to meet increasing demand. OIRP seeks to help National Programs develop a global perspective for bioenergy R&D prioritized to domestic stakeholder needs.

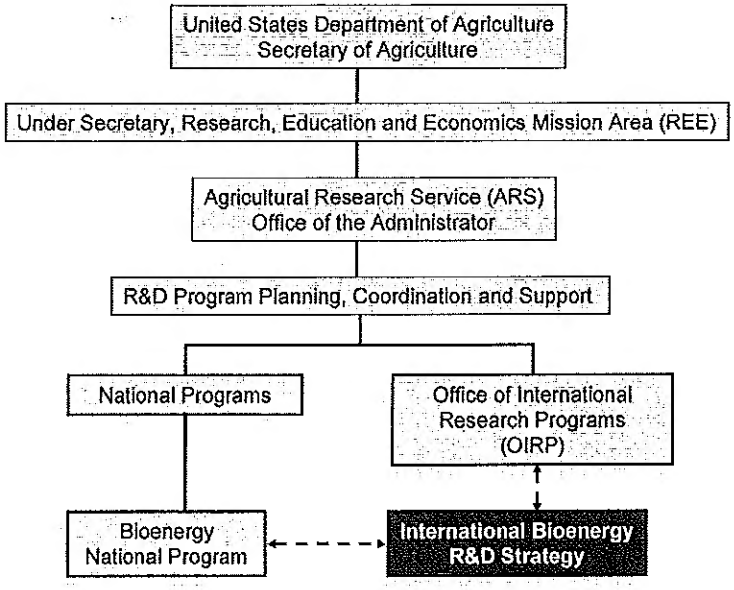


Figure 2. Although National Programs and OIRP are separate offices, they must work synergistically to ensure international bioenergy efforts support the domestic agenda. The *International Bioenergy R&D Strategy* provides a mechanism to enhance coordination between the two offices.

2.0 Strategy Development Process

The primary objectives of the *International Bioenergy R&D* Strategy are to identify international bioenergy R&D strategic thrust areas which support the three component areas of the Bioenergy National Program Action Plan (draft), and to propose action steps to increase OIRP effectiveness in those particular areas.

The strategy was based on the following inputs:

- Assessment of the current state of international bioenergy R&D partnerships (through a data call to ARS scientists engaged in bioenergy R&D (see Appendix III for report))
- Discussions with select ARS scientists engaged in international bioenergy partnerships
- Discussions with select ARS National Program Leaders involved in Bioenergy National Program strategic planning

The identification of strategic thrust areas relied on an integration of all data sources, including in-house analysis, conversations with stakeholders, and consideration of several parameters. A decision matrix for R&D strategic thrust area identification is represented in Figure 3.

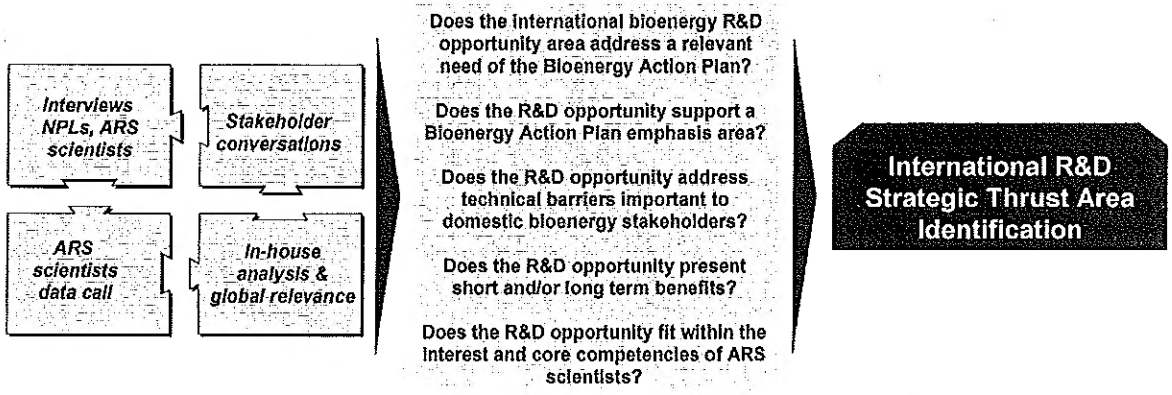
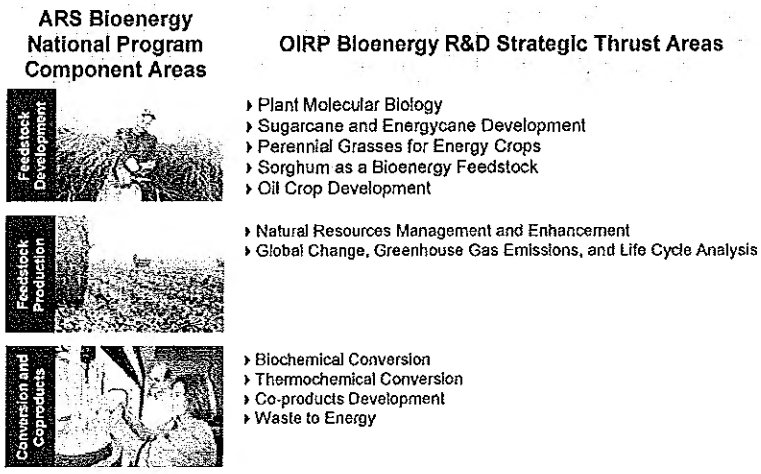


Figure 3. Diagram illustrating the thought process for identification of international R&D target areas.

Particular consideration was granted to potential international partnership opportunities which add value to and support domestic stakeholder needs not captured in the Bioenergy Action Plan. Therefore, the international partnership opportunity areas identified have added merit as they represent R&D opportunity areas that can significantly expand the scope of the Bioenergy National Program to cover more R&D areas in a cost effective manner.

3.0 Opportunity Analysis & Strategic Thrust Area Identification

Eleven international bioenergy R&D strategic thrust areas were identified corresponding to the three component areas of the Bioenergy National Program (at right). Each of the thrust areas can significantly extend and enhance the impact of ARS bioenergy R&D. OIRP will target these thrust areas with specific actions to enable and promote the success of these endeavors.



International bioenergy R&D strategic thrust areas for Feedstock Development, Feedstock Production, and Conversion and Co-products are presented in the following sections; please see Appendices IV, V, and VI for the full reports.

3.1 Feedstock Development Strategic Thrust Areas

Bioenergy feedstocks provide the essential materials required for humanity to create fuels, power, and products, and are arguably the most important contribution to the biofuels industry, which relies on an ample supply of quality feedstock. See Appendix IV for a detailed description of Feedstock Development Strategic Thrust Areas.

3.11 Plant Molecular Biology	
Challenge/ Opportunity Area for OIRP Action	Basic plant molecular biology R&D stands to enhance the potential to develop engineered crops for fuels and products. ARS scientists have successfully worked with European Union (EU) partners to secure funding from the European Commission (EC); however, these funds are only available to EU members.
Bioenergy Action Plan Emphasis Area	▸ Fundamental research to control key plant traits impacting energy content and co-product value ▸ Improved understanding of the plant cell wall ▸ Promotes intra-agency collaboration across National Programs
Key Technical Barriers Addressed	▸ Limited ability to modify plant cell walls for bioenergy and co-product traits ▸ Lack of high throughput cell wall assays to identify plant genetic resources ▸ Identity of all genes responsible for cell wall biosynthesis and structure
Value Added to Domestic Stakeholders	Genomic R&D being funded by EC framework 7 is expensive to replicate, therefore, even modest investment in partnership could be a tremendous benefit to ARS scientists and the US
OIRP Strategic Action	▸ Support ARS scientists' participation with EC framework 7 R&D by identifying funding opportunities and/or leveraging existing funding opportunities towards this effort and continue to promote information exchange ▸ Consider the requirements and possibility for a US/ARS – European Union bioenergy science exchange program modeled on EMBRAPA Labex

3.12 Sugarcane and Energycane Development	
Challenge/ Opportunity Area for OIRP Action	There are numerous R&D opportunities to develop cold tolerant varieties and high biomass varieties of sugarcane and energycane for use as biofuels feedstock.
Bioenergy Action Plan Emphasis Area	▸ Develop new germplasm and varieties with value added traits to enhance yields ▸ Fundamental research to control key plant traits impacting energy content ▸ Promotes intra-agency collaboration across National Programs
Key Technical Barriers Addressed	▸ Narrow genetic diversity in current commercial sugarcane crop ▸ New tools are needed to incorporate genetic diversity of novel or un-adapted germplasm into new varieties
Value Added to Domestic Stakeholders	ARS scientists have identified a significant need for scientific germplasm collection expeditions to higher elevation areas of China, India, and Thailand, to pursue germplasm of *Saccharum spontaneum*, and related genera
OIRP Strategic Action	▸ Investigate opportunities for US cane stakeholders, such as the American Sugar Alliance, to fund international germplasm exploration ▸ Liaise with the ARS Office of Technology Transfer (OTT) to facilitate germplasm exchange in respect to proprietary concerns by India and Thailand

3.13 Perennial Grasses for Energy Crop Development	
Challenge/ Opportunity Area for OIRP Action	Perennial grasses such as switchgrass and Miscanthus are attractive sources of cellulosic biomass; R&D in this area is critical to achieving the long term US bioenergy goals as articulated by the Renewable Fuel Standard.
Bioenergy Action Plan Emphasis Area	▸ Develop new germplasm and varieties with value added traits to enhance yields ▸ Fundamental research to control key plant traits impacting energy content ▸ Promotes intra-agency collaboration across National Programs
Key Technical Barriers Addressed	▸ New tools are needed to incorporate genetic diversity of novel or un-adapted germplasm into new varieties for enhanced bioenergy crop traits ▸ Limited ability to modify plant cell walls for bioenergy traits ▸ Lack of high throughput cell wall assays to identify plant genetic resources
Value Added to Domestic	The anticipated establishment of the cellulosic biomass industry will open new opportunities for biomass to become a

Stakeholders	significant revenue generator for producers.
OIRP Strategic Action	▸ Investigate and facilitate opportunities for germplasm exchange between the US, China, and Japan ▸ Liaise with ARS Office of Technology Transfer (OTT) to develop best practices for intellectual property protection

3.14 Sorghum as a Bioenergy Feedstock	
Challenge/ Opportunity Area for OIRP Action	Grain sorghum and/or sweet sorghum have demonstrated significant potential as bioenergy feedstocks both in the US and aboard, making the crop an attractive area of collaborative R&D efforts.
Bioenergy Action Plan Emphasis Area	▸ Develop new germplasm and varieties with value added traits to enhance yields ▸ Fundamental research to control key plant traits impacting energy content ▸ Promotes intra-agency collaboration across National Programs
Key Technical Barriers Addressed	▸ Narrow genetic diversity in current commercial crop ▸ New tools are needed to incorporate genetic diversity of novel or un-adapted germplasm into new varieties
Value Added to Domestic Stakeholders	Sweet sorghum may prove to be an economically viable feedstock for the biofuel industry, and provide domestic sorghum producers with options for increased profitability
OIRP Strategic Action	▸ Coordinate an International Sorghum for Biofuel Conference to increase technology exchange between international and domestic sorghum scientists and producers ▸ Leverage results and networks from the conference to establish a 'virtual' global sorghum laboratory for bioenergy production.

3.15 Oil Crop Development	
Challenge/ Opportunity Area for OIRP Action	Biodiesel producers can not compete due to the high cost of soybean oil feedstock, which will effectively restrict, and potentially derail expansion of the US biodiesel industry.
Bioenergy Action Plan Emphasis Area	▸ Develop new germplasm and varieties with value added traits to enhance yields ▸ Fundamental research to control key plant traits impacting energy content ▸ Promotes intra-agency collaboration across National Programs
Key Technical Barriers Addressed	▸ New tools are needed to incorporate genetic diversity of novel or un-adapted germplasm into new varieties for enhanced bioenergy crop traits ▸ Limited ability to increase oil yield and modify oil structure for

	bioenergy traits ▸ Lack of high throughput assays to identify plant genetic resources
Value Added to Domestic Stakeholders	▸ Domestic biodiesel production would benefit from oil crop diversification by deflecting some upward pressure off soybean prices ▸ Domestic growers would also benefit by virtue of the immediate need for the resource ▸ Developing oil crops yet un-adapted to US soils may also be a multiplier for the economy as services develop to support such crops
OIRP Strategic Action	▸ Facilitate international partnerships in this area, and identify funding sources for these partnerships ▸ Investigate the potential to work with Indian scientists to transition jatropha to a production crop ▸ Engage the State Department and the Department of Homeland Security to fund a zero/low-ricin castor bean R&D collaboration with Brazil, with the dual benefit of reducing potential ricin production while increasing needed feedstock for US biodiesel

3.2 Feedstock Production Strategic Thrust Areas

When considering the additional demands on agricultural systems to produce bioenergy feedstock, whether as agricultural residues or dedicated bioenergy crops, one must consider the impact across the entire production system, from farm to field to watershed. See Appendix II for a detailed description of Feedstock Production Strategic Thrust Areas.

3.21 Natural Resources Management and Enhancement	
Challenge/ Opportunity Area for OIRP Action	Understanding how humans can protect and enhance agricultural systems in the face of increasing demand for food, feed, fiber, and fuel is absolutely essential to successful long term sustainability of the world's natural resources.
Bioenergy Action Plan Emphasis Area	▸ Feedstock production in close cooperation with feedstock development ▸ Sustainable agronomic systems with feedstock development ▸ Multi-disciplinary and multi-geographic agricultural R&D
Key Technical Barriers Addressed	▸ Insufficient water availability ▸ Unsuitable or unproductive soil ▸ Lack of effective harvesting, handling, transport and storage

	of biomass material
Value Added to Domestic Stakeholders	▸ Conserving and enhancing soil and water resources both in the US and abroad can act as a multiplier for economic return by building stability and confidence in rural communities ▸ Feedstock logistics R&D is expected to have dramatic benefits for a range of stakeholders, from the producer to the refiner, and will be critical to fostering new industry development
OIRP Strategic Action	▸ Work with NPS Natural Resources to investigate global interest and identify international partners to extend the impact of ARS CEAP and REAP programs[4],[5] ▸ Reference the CEAP Canadian Watershed Evaluation of Best Management Practices (WEBS) project as a model for international partnerships in this area ▸ Investigate the potential to collaborate on existing international efforts, such as the international ambitions of the National Integrated Drought Information System (NIDIS), and the Roundtable on Sustainable Palm Oil

3.22 Global Change, Greenhouse Gas Emissions, and Life Cycle Analysis	
Challenge/ Opportunity Area for OIRP Action	Precisely how global change will impact agriculture is unknown, but the impact in the US and abroad is an extremely important consideration when addressing sustainability; international partnerships are required to meet the substantial data needs, to move from theoretical modeling to real time observation and fact based projection for food and fuel.
Bioenergy Action Plan Emphasis Area	▸ Sustainable agronomic systems with feedstock development ▸ Multi-disciplinary and multi-geographic agricultural R&D
Key Technical Barriers Addressed	Insufficient knowledge base to recommend optimal production practices for sustainable use of natural resources
Value Added to Domestic Stakeholders	Accurate, real time, and global data should be considered a priority area for the success of both the RFS and the burgeoning global biofuels market
OIRP Strategic Action	Attract international partners to the GRACEnet project[6], with the goal of establishing dedicated individuals to monitor greenhouse gas emissions directly from bioenergy feedstock production systems, to aid the accuracy of biofuels' life cycle assessment, especially when indirect land use change is

[4] http://www.nrcs.usda.gov/TECHNICAL/NRI/ceap/; Conservation Effects Assessment Project
[5] http://www.ars.usda.gov/SP2UserFiles/Place/36450000/brochures/REAP%20Brochure%20June%202007.pdf; Renewable Energy Assessment Project, USDA-ARS
[6] http://www.ars.usda.gov/research/projects/projects.htm?accn_no=411610; Carbon Sequestration and Greenhouse Gas Mitigation by Agricultural Management

	considered

3.3 Conversion and Co-products Strategic Thrust Areas

Biomass conversion involves the transformation of biomass to fuels and other high value co-products. Conversion technologies can be either biochemical (with the use of enzymes to produce fermentable sugars that can be converted into fuels) or thermochemical (with the use of heat to produce syngas or bio-oil for subsequent upgrading to fuels and products). Technologies for converting wastes to energy include digesters (converting manure and agricultural residues to biogas – methane) and thermochemical conversion technologies (converting manure and agricultural residues to syngas or bio-oil). See Appendix VI for a detailed description of Conversion and Co-products strategic thrust areas.

3.31 Biochemical Conversion	
Challenge/ Opportunity Area for OIRP Action	Development of enzymes and microorganisms to increase conversion efficiency of biomass to fuels and products is important to drive down costs for the long term success of biorefineries.
Bioenergy Action Plan Emphasis Area	▸ Enabling processes for full or partial fractionation, pretreatment or conversion at-or-near the farm ▸ Enables the development of value added co-products from biorefineries
Key Technical Barriers Addressed	▸ Relatively high resistance of plant cell walls to chemical and enzymatic hydrolysis imposes high conversion ▸ Dilute aqueous systems require high energy inputs for separation/recovery ▸ Cellulosic conversion technologies do not handle feeds of variable composition efficiently
Value Added to Domestic Stakeholders	Key technology poised to significantly advance the ability to convert lignocellulosic biomass to fuel and other high-value biobased products; continued technological development is required for technology commercialization
OIRP Strategic Action	Investigate the scope of global R&D in this area to better target international partnership opportunities for ARS scientists, and liaise with OTT to help ensure intellectual property is protected.

3.32 Thermochemical Conversion	
Challenge/ Opportunity Area for OIRP Action	Thermochemical conversion has great potential for on-farm bioenergy processing, but requires technological advancements to achieve economic and reliable biomass deconstruction and upgrading to fuels and products.
Bioenergy Action Plan Emphasis Area	▸ Enabling processes for full or partial fractionation, pretreatment or conversion at-or-near the farm
Key Technical Barriers Addressed	▸ Lack of cost-effective, close to the farm, thermochemical processes for conversion of agricultural feedstocks to

	biopower or marketable, higher energy density (Kcal/kg) intermediates ▸ Lack of cost-effective thermochemical processes for small-scale production of liquid fuels ▸ Lack of suitable catalysts for thermochemical conversion of feedstocks ▸ Cellulosic conversion technologies do not handle feeds of variable composition efficiently
Value Added to Domestic Stakeholders	Key technology poised to significantly advance the ability to convert lignocellulosic biomass to fuel and other high-value biobased products; potential for on-farm deployment could serve on site energy needs.
OIRP Strategic Action	Work with NPS and ARS scientists to determine the most pressing R&D needs associated with this area that could be enhanced by international partnership; leverage contacts to help ARS scientists expand professional connections with EU expertise.

3.33 Co-product Development	
Challenge/ Opportunity Area for OIRP Action	Biorefinery co-products can significantly enhance the economics of the process and may be the key to technology viability and commercialization.
Bioenergy Action Plan Emphasis Area	▸ Enabling the development of value-added co-products from biorefineries
Key Technical Barriers Addressed	▸ Quality, consistency and flowability issues limit market utility of DDG co-product ▸ Lack of commercially viable, value-added co-products from biochemical conversion of lignocellulosics ▸ Lack of commercially viable, value-added co-products from thermochemical conversion of lignocellulosics ▸ Lack of standardized, quality-assurance methods for raw materials and/or products
Value Added to Domestic Stakeholders	The economic benefits of producing high value co-products is key to supporting the economics of the industry, and a likely driver of the economic security investors will require prior to investment in a new technology poised to compete in the volatile biofuels market.
OIRP Strategic Action	New opportunities, as well as enhancements to existing collaborative efforts, will be investigated in China, Europe, South Africa and EU countries; coordinate with NPS and OTT to create guidelines for international collaboration in coproducts R&D to ensure ARS developed technology and any intellectual property is protected.

3.34 Waste to Energy	
Challenge/ Opportunity Area for OIRP Action	Significant potential exists to convert smaller volumes of animal manure and agricultural residues to methane to be used as an on-farm energy source
Bioenergy Action Plan Emphasis Area	▸ Supporting the development of on-farm technologies that increase the energy independence of farms, reduce the release of methane and other greenhouse gasses into the atmosphere, and promote environmental stewardship
Key Technical Barriers Addressed	▸ Lack of cost effective and technologically advanced solutions for on-farm disposal of animal wastes and other agricultural residues which provide value on-farm through the production of heat and power while reducing the atmospheric release of harmful greenhouse gasses
Value Added to Domestic Stakeholders	On-farm power production from waste (manure and agricultural residues) provides economic benefits to rural Americans by creating the opportunity for them to become energy independent through the production of heat, power and fuels on-farm, while practicing environmental stewardship
OIRP Strategic Action	Expand international involvement in waste to energy by facilitating knowledge sharing of on-farm technology applications and leveraging pertinent international experience; investigate strategies for securing international partners to help fund ARS technology development

3.4 Additional Observations

While the strategic thrust area identification targeted areas which complement and support the Bioenergy Action Plan, the analysis also called attention to the potential needs for partnerships with countries/regions relating to domestic policy and national agenda priorities (see Appendix III for report), such as:

- Scarcity of reported partnerships in Mexico and Central America despite national MOU with Brazil to help 'third' countries develop bioenergy capacity: Greg Manuel, Special Advisor to the Secretary, Office of the International Energy Coordinator, U.S. Department of State, reported that 30 projects have been identified by consultants in 3rd Countries (Dominican Republic, Haiti, El Salvador, and St. Kitts) and 8 are currently under development to support biofuels technology development. ARS should investigate these developments.
- Sustainable feedstock production collaborations are very limited. Sustainable production, including greenhouse gas emissions (GHG) and mitigation, is an important component of the EISA RFS which mandates significant baseline GHG reductions versus conventional petroleum derived fuels. At this point it is unclear how global land use change (LUC) may affect RFS compliance of domestically produced biofuels.

- The single collaboration with India is regarded by NPS as one having little to no impact, yet many opportunities exist to partner with this innovative nation on various bioenergy R&D feedstock projects.
- No reported collaborations in Africa despite the fact that bioenergy production may have greater impact in many economically challenged countries.
- China maintains the most collaboration in this area driven largely by excitement regarding China's growing economy and emerging markets. OIRP encourages collaboration with China but indicated that these collaborations should be closely managed to ensure mutual benefit and intellectual property protection.

4.0 Organizational Enablers for OIRP Implementation

With the goal in mind to better support the Bioenergy National Program, OIRP identified several key organizational enablers which will be leveraged to achieve greater effectiveness and functionality across the agency. OIRP received valuable insight from ARS scientists and National Program Leaders regarding OIRP operation.

4.1 Enhanced NPS Integration	
OIRP specialists bring significant international experience, insight, and linguistics to National Program Staff; however, this knowledge is organized around world regions as opposed to national program areas	
Strategic Actions	▸ Greater integration between OIRP International Affairs Specialists and NPS to encourage a more fruitful exchange of expertise and information between the two staffs. NPS would benefit from greater knowledge of international activity and OIRP would gain valuable insight into technical issues specific to national programs ▸ OIRP will directly engage NPS to develop great expertise in specific national program areas. OIRP has historically been disconnected from national program strategic planning ▸ OIRP specialists will participate in national program workshops and stakeholder meetings to help develop a better perspective of NPS goals based on domestic stakeholder needs. A greater knowledge of national program stakeholder characteristics and needs will enable OIRP specialists to work more effectively by targeting international R&D partnership opportunities to support respective stakeholders
Current Activities	▸ OIRP has already acknowledged that better integration will facilitate greater communication and increase opportunities for partnership. OIRP specialists have been assigned to respective National Program Staff divisions and are now attending weekly meetings of the ARS Bioenergy Task Force

4.2 Intellectual Property Management	
Amongst some ARS scientists, there is a lack of understanding of issues regarding international intellectual property management and protection; need for greater dialogue between NPS and ARS scientists on issues regarding technology and intellectual property protection.	
Specific Concerns	▸ Proprietary concerns over germplasm exchange ▸ Perceived difficulties with international patents ▸ Concerns over lack of technology protection in the absence of patents ▸ Technology and intellectual property protection, specifically in the areas of biochemical conversion and co-products R&D ▸ ARS scientists also indicated that some CRADA partners have expressed concerns regarding the participation of international scientists on CRADA projects
Strategic Actions	▸ OIRP will work closely with OTT and NPS to develop a set of guidelines for ARS scientists to follow to ensure that progress can be made which does not compromise potential future intellectual property and profits. These actions are intended to reduce and potentially eliminate intellectual property issues as barriers to international partnerships.

4.3 Measuring Impact	
Performance metrics are required to monitor the progress of current international projects as well as assess both the success of the international partnership and the measure of positive impact on society.	
Specific Concerns	▸ Bioenergy R&D partnerships appear anecdotally successful (Appendix III); however, NPS recognizes that these accomplishments, such as number of publications, while commendable, fail to measure the impact of the collaboration on a macro-level
Strategic Actions	▸ Assess current methods for assigning performance metrics to international projects to more effectively track success and impact ▸ Develop outcome measures to properly capture and assess international R&D activities and performance in real time through a framework approach that is flexible to a myriad of collaborative arrangements

4.4 Promoting OIRP Capabilities Across the Federal Government	
OIRP is not proactively promoting/marketing its capabilities to work with other Federal agencies	
Specific Concerns	▸ The majority of R&D funding for OIRP sponsored international partnerships comes from outside the agency, arriving from the Department of State, Defense, etc., placing OIRP is a funding 'past through' position
Strategic Actions	▸ OIRP will engage in well positioned dialogue with all Federal agencies to drive opportunities to ARS ▸ OIRP specialists will develop mechanisms to better market their expertise and the services ARS scientists are capable of providing

4.5 Information Exchange/Management	
ARS scientists experience confusion between local, area, and national headquarters on international administrative procedures	
Specific Concerns	▸ Scientists taking international sabbaticals have experienced problems likely attributable to ineffective communication of rules, regulations, and procedures ▸ National Program Leaders would benefit from greater OIRP consultation when meeting with international delegations ▸ There is a misperception among ARS scientists that international activities do not count positively towards a performance review
Strategic Actions	▸ OIRP will develop a "Travel Fact Sheet" and "FAQs" web site, and conduct at least one training session per year with ARS local and area office staff, to ensure that administrative procedure and policy is well understood ▸ OIRP specialists will brief National Program leaders on the nature of a visit, and the opportunities, prior to their meeting with international delegates ▸ ARS scientists will be made aware of the benefits associated with international partnership with regard to yearly performance evaluations as well as the personal rewards likely to be gained from this experience